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# **Dynamic Visual Acuity: Measuring a Different Source of Visual Impairment**

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# Primary Messages

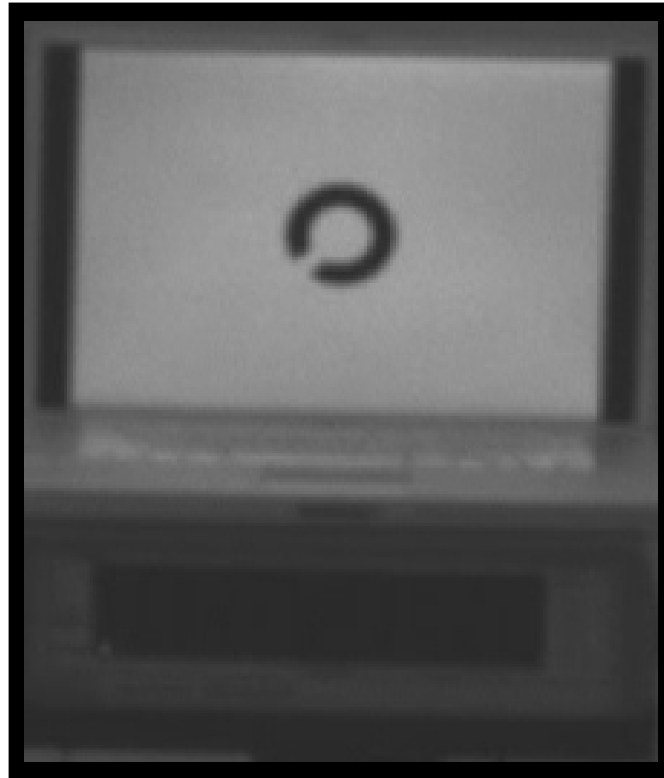
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- Seeing clearly requires more than just being able to focus on an object
- Acuity is affected during dynamic activities early postflight
- Dynamic visual acuity is affected by multiple variables

# Acuity Formula

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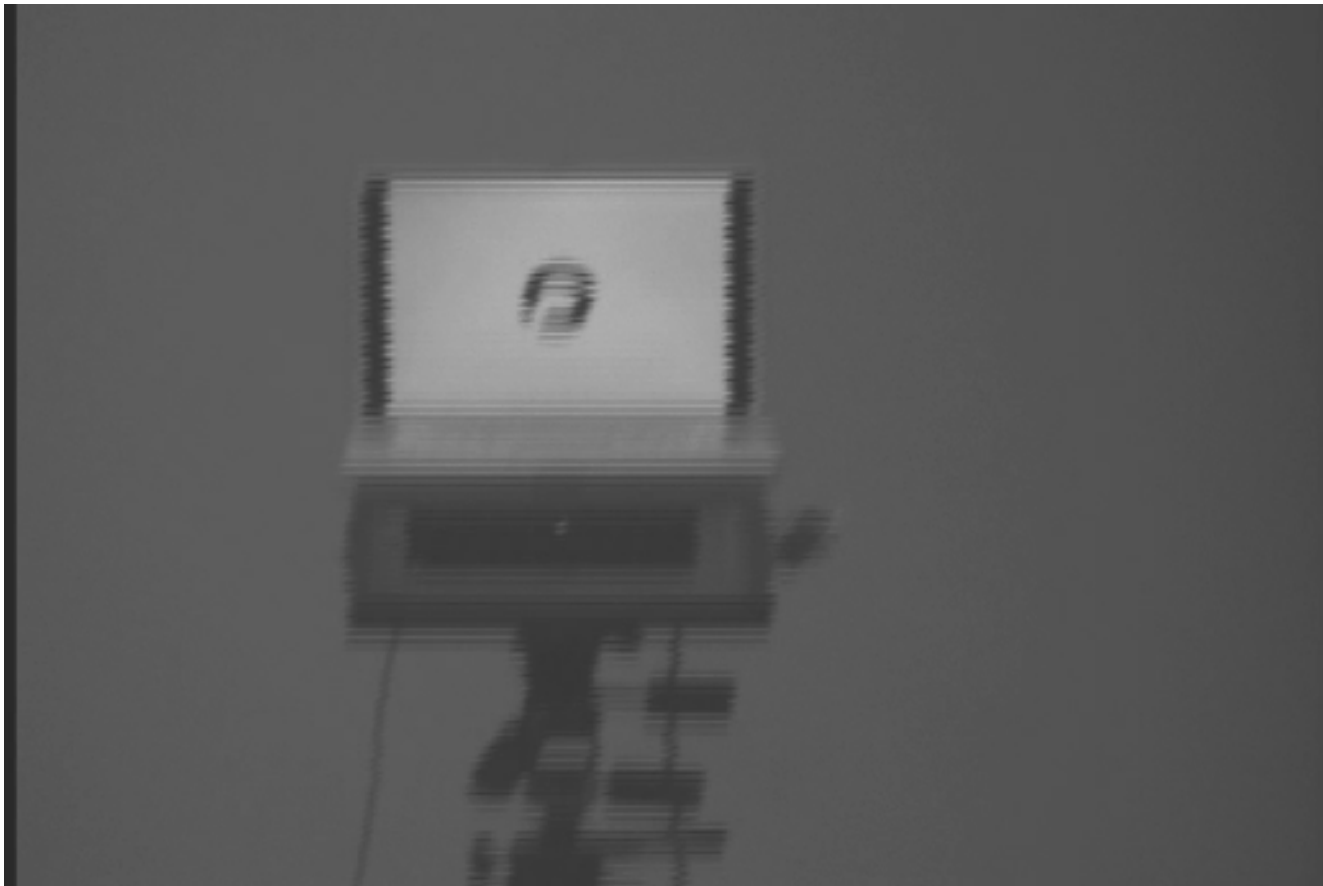
Acuity = Accommodation  
**(ability to focus)**



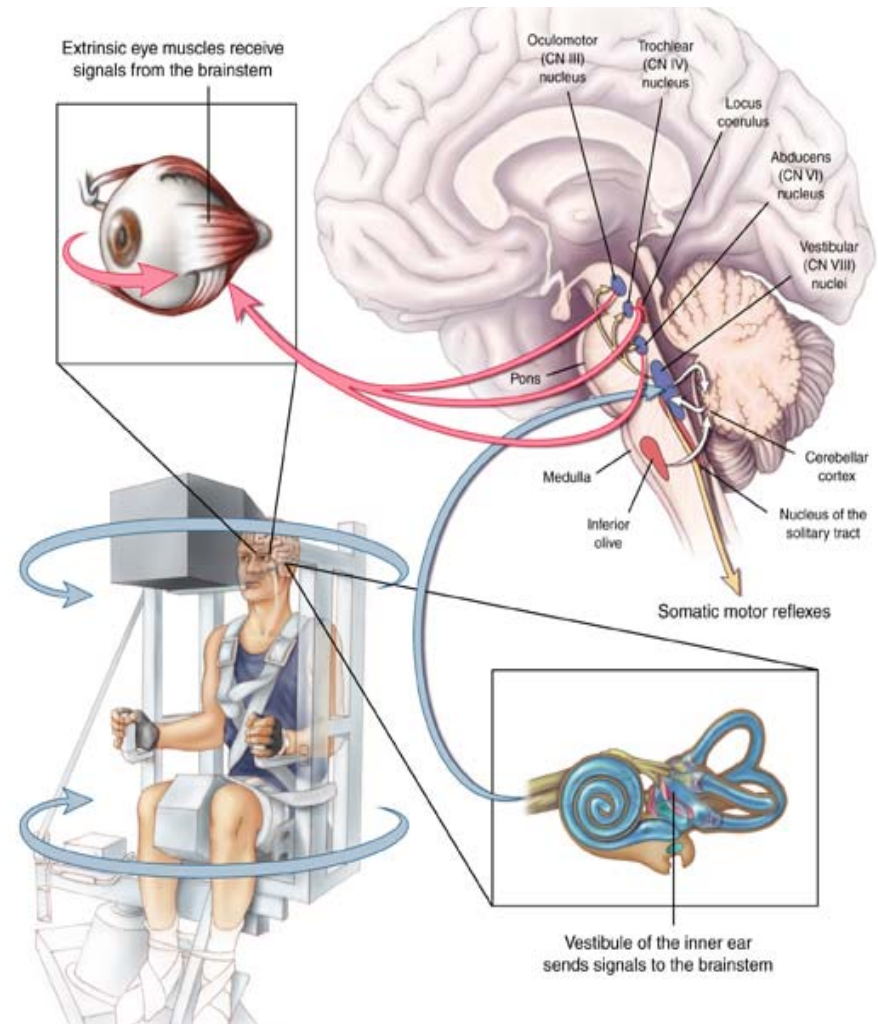
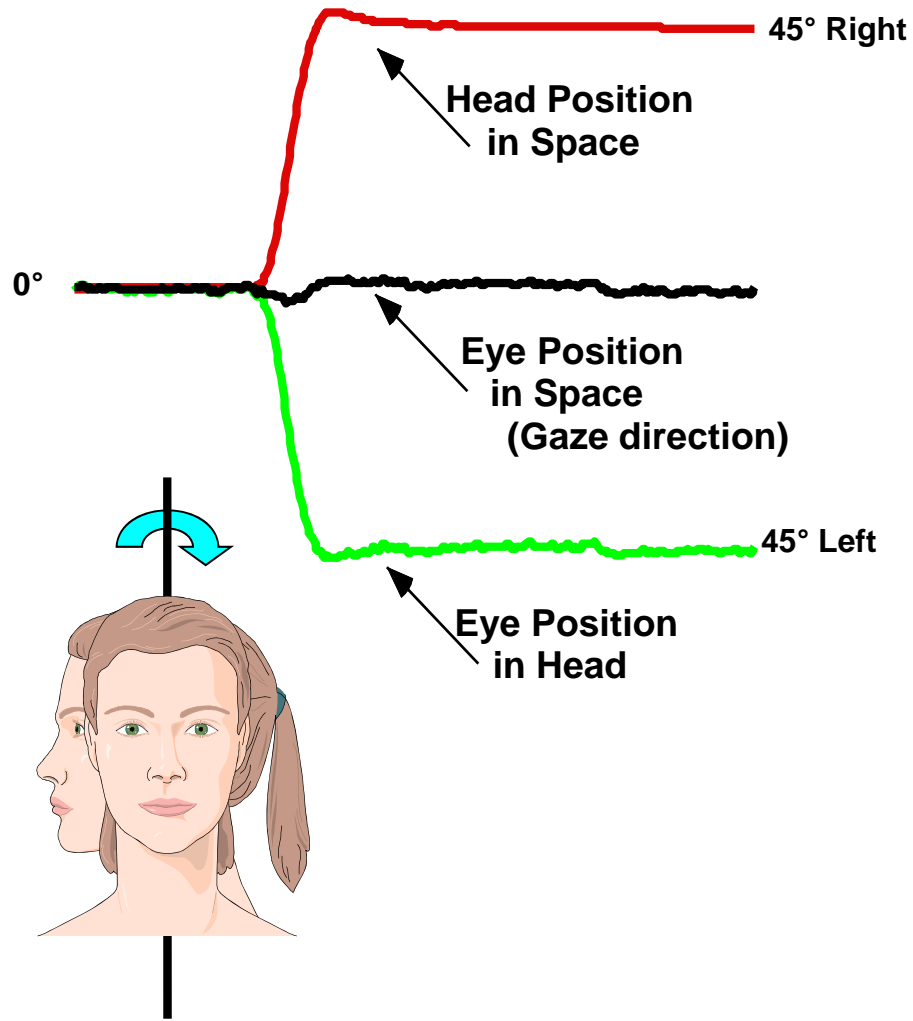
# Acuity Formula

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Acuity = Accommodation + Gaze Stabilization  
(ability to focus) (maintain gaze)



# The Vestibulo-Ocular Reflex

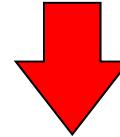


# The Concern

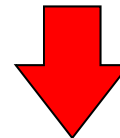
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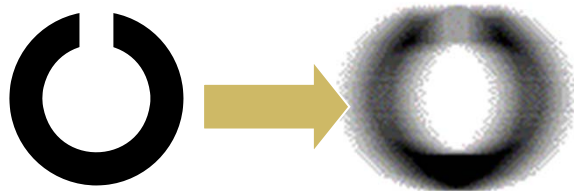
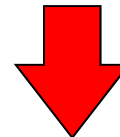
**Exposure to space flight**



**Central reinterpretation  
vestibular information**



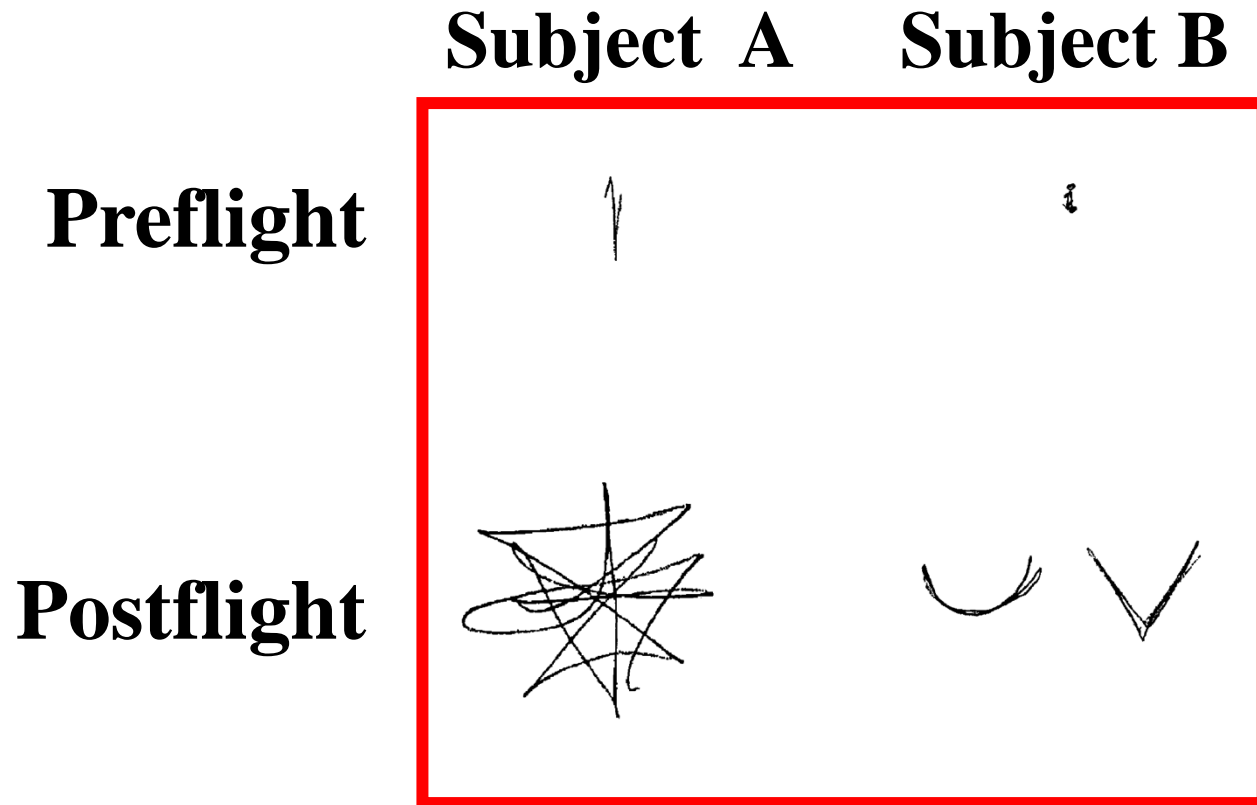
**Alteration in gaze stabilization**



***Reduction in visual acuity  
during head motion***

# Early Evidence

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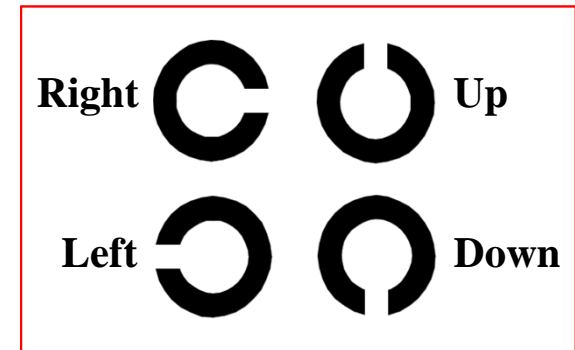
**Drawings of LED target from treadmill-walking subjects**

# Dynamic Visual Acuity Test

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- **Computer-based test using Landolt C optotypes**

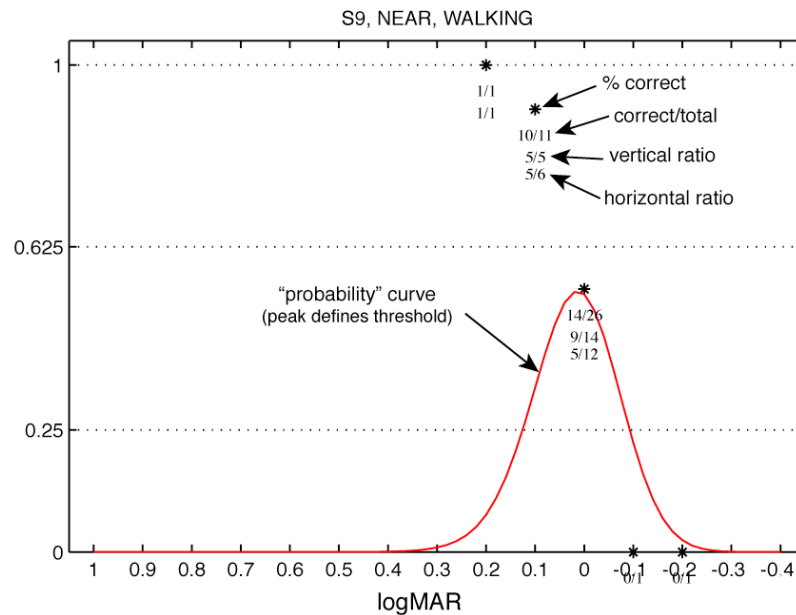
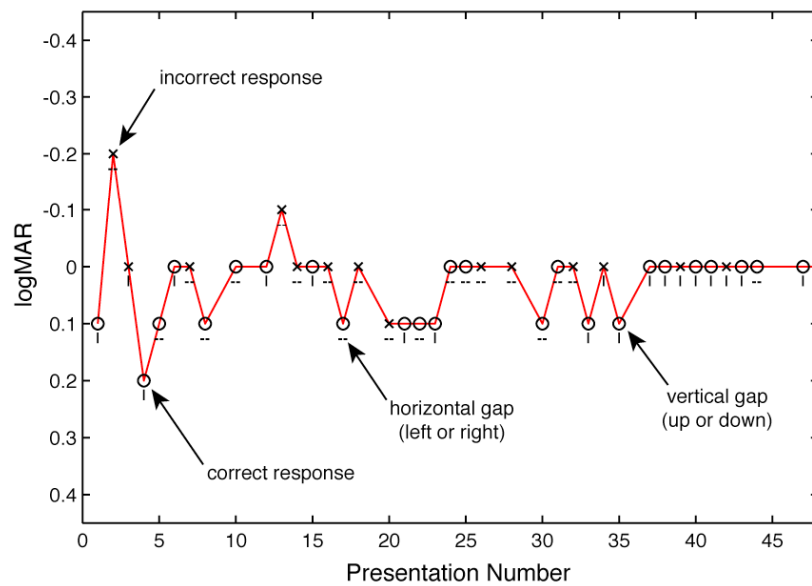
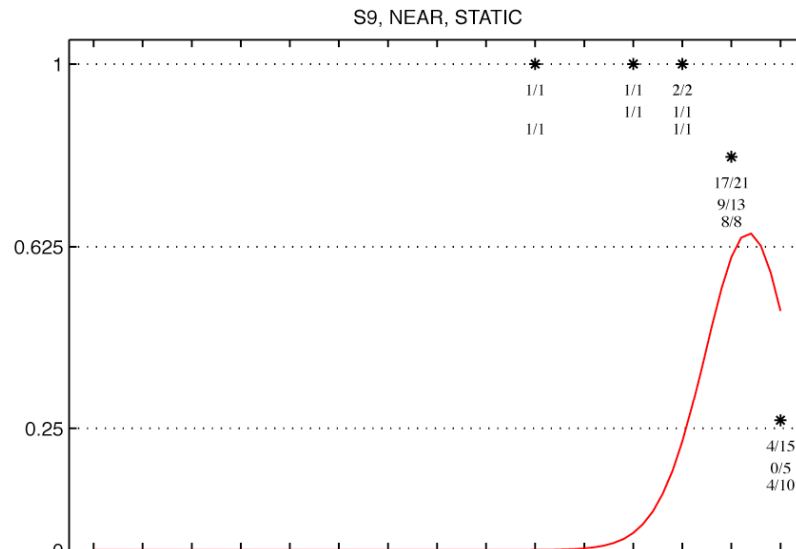
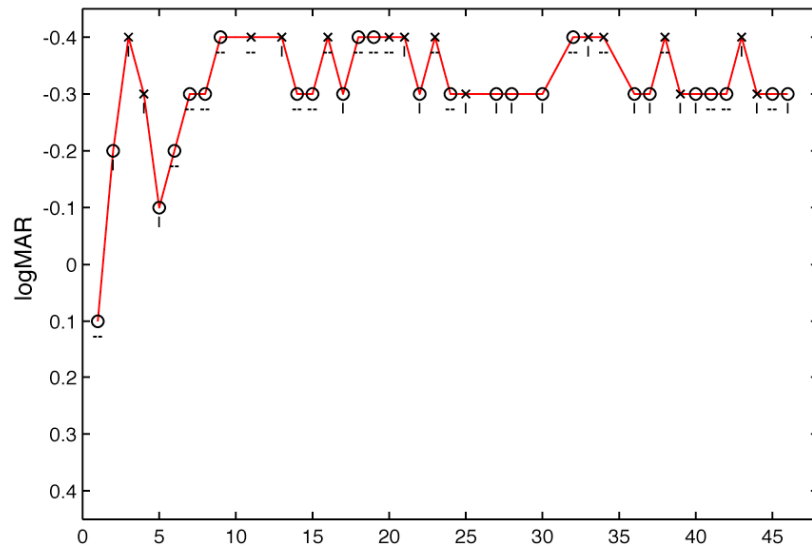
- **Subjects walk on a treadmill at 1.8 m/s and identify the gap location in the “Cs” presented for 500 ms on a laptop at 4 m**



- **A threshold-detecting algorithm controls the size of the sequentially-presented optotypes**
- **Static acuity (seated) is subtracted from the walking acuity**



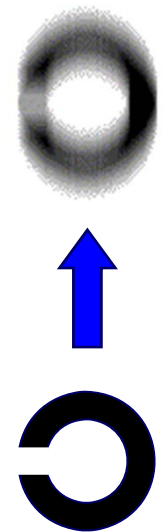
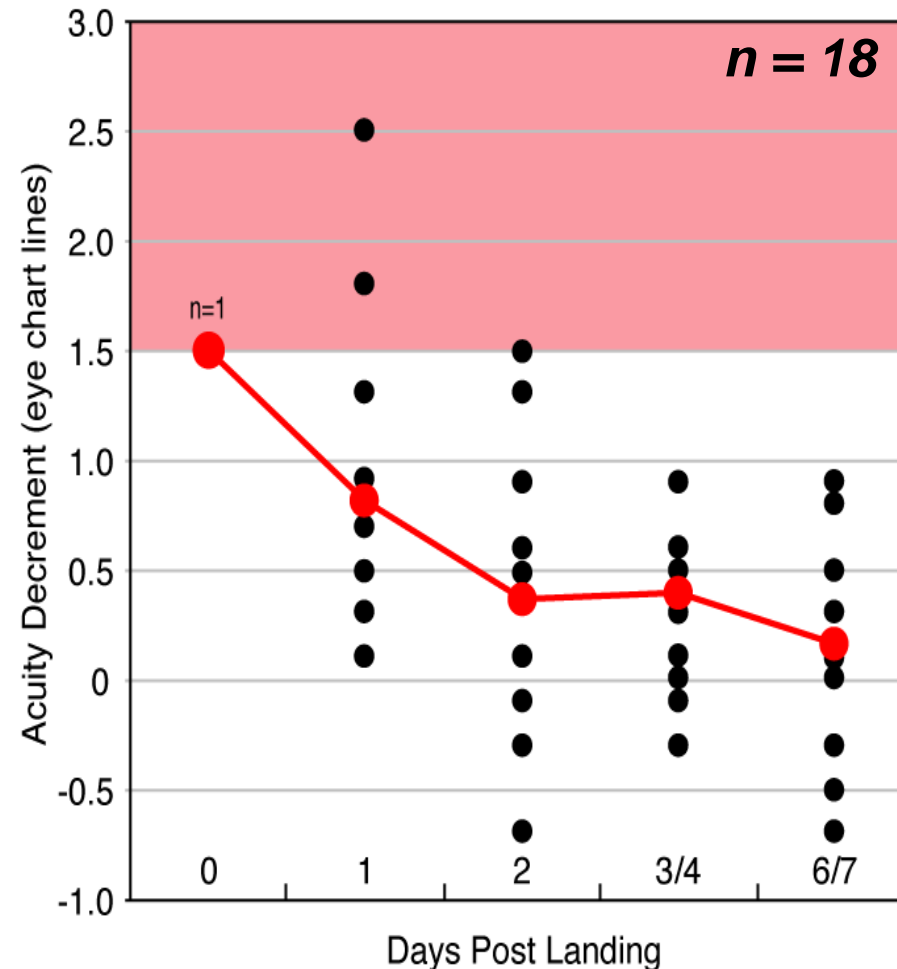
# DVA Test Output



# DVA after Long-Duration Space Flight (ISS)

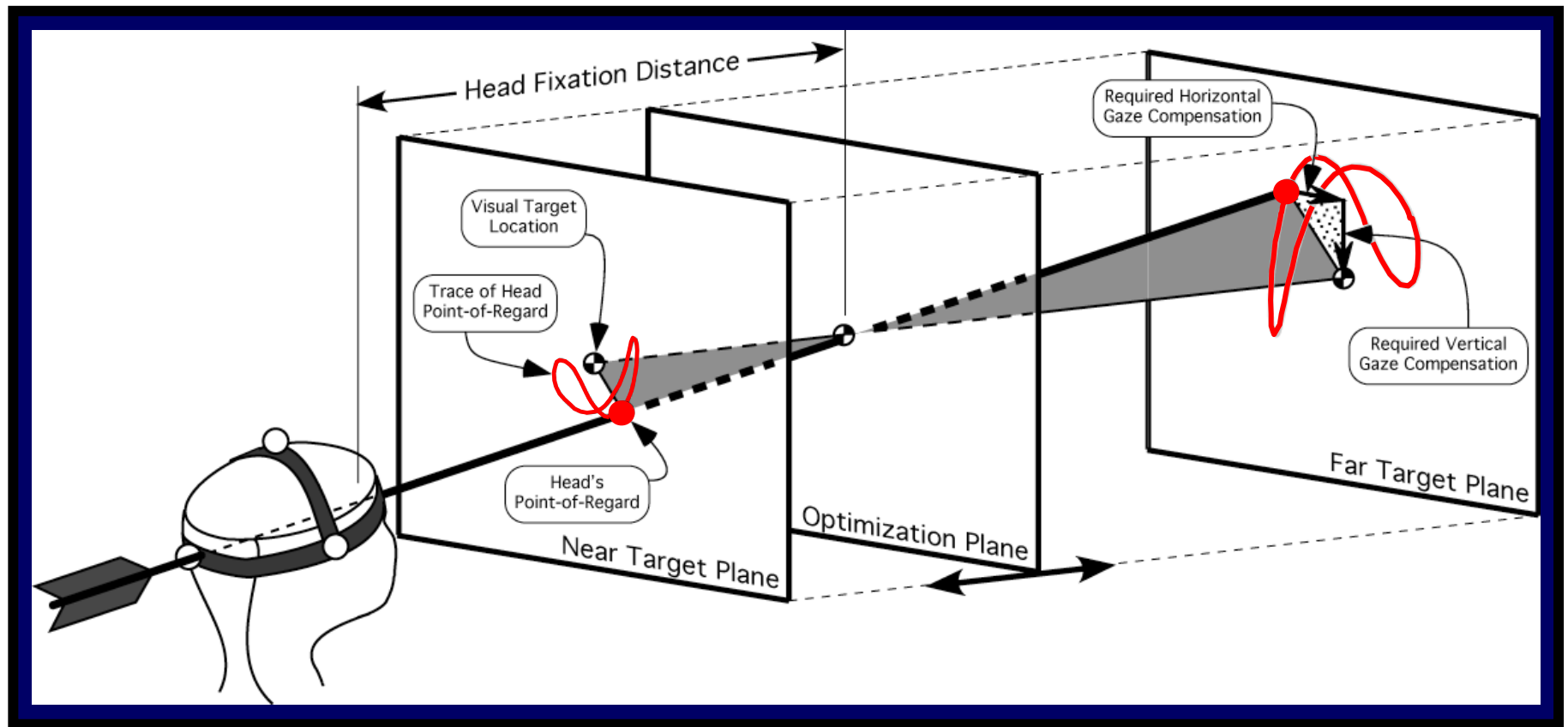
- Only 1 of 3 were able to complete the test on R+0
- Performance levels for patients with vestibular dysfunction are indicated in red

*Astronauts show reduction in visual acuity during postflight walking due to changes in gaze control*



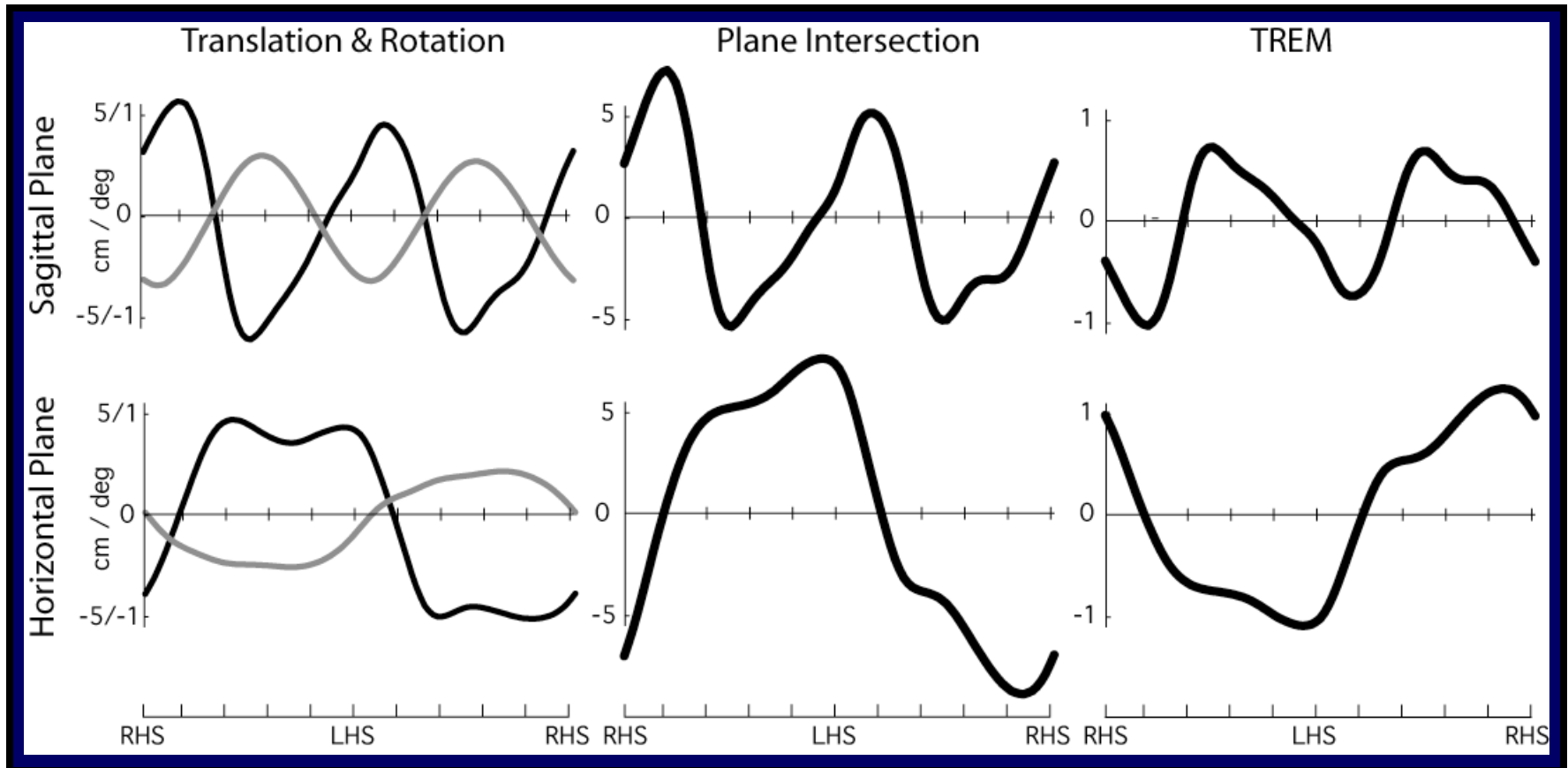
# Target Distance Affects Gaze Task

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# Required Eye Movements

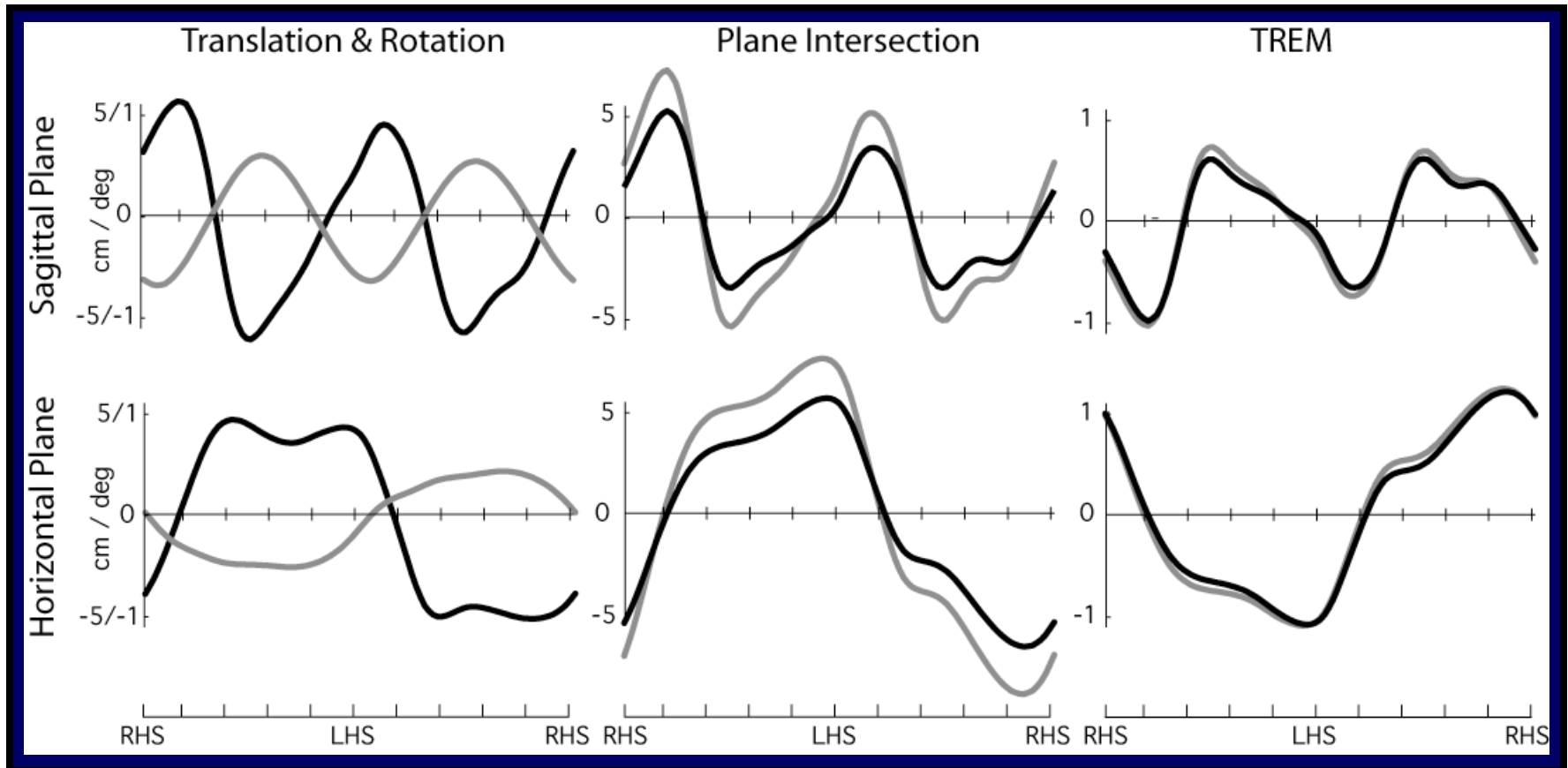
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**4.0 m**

# Required Eye Movements

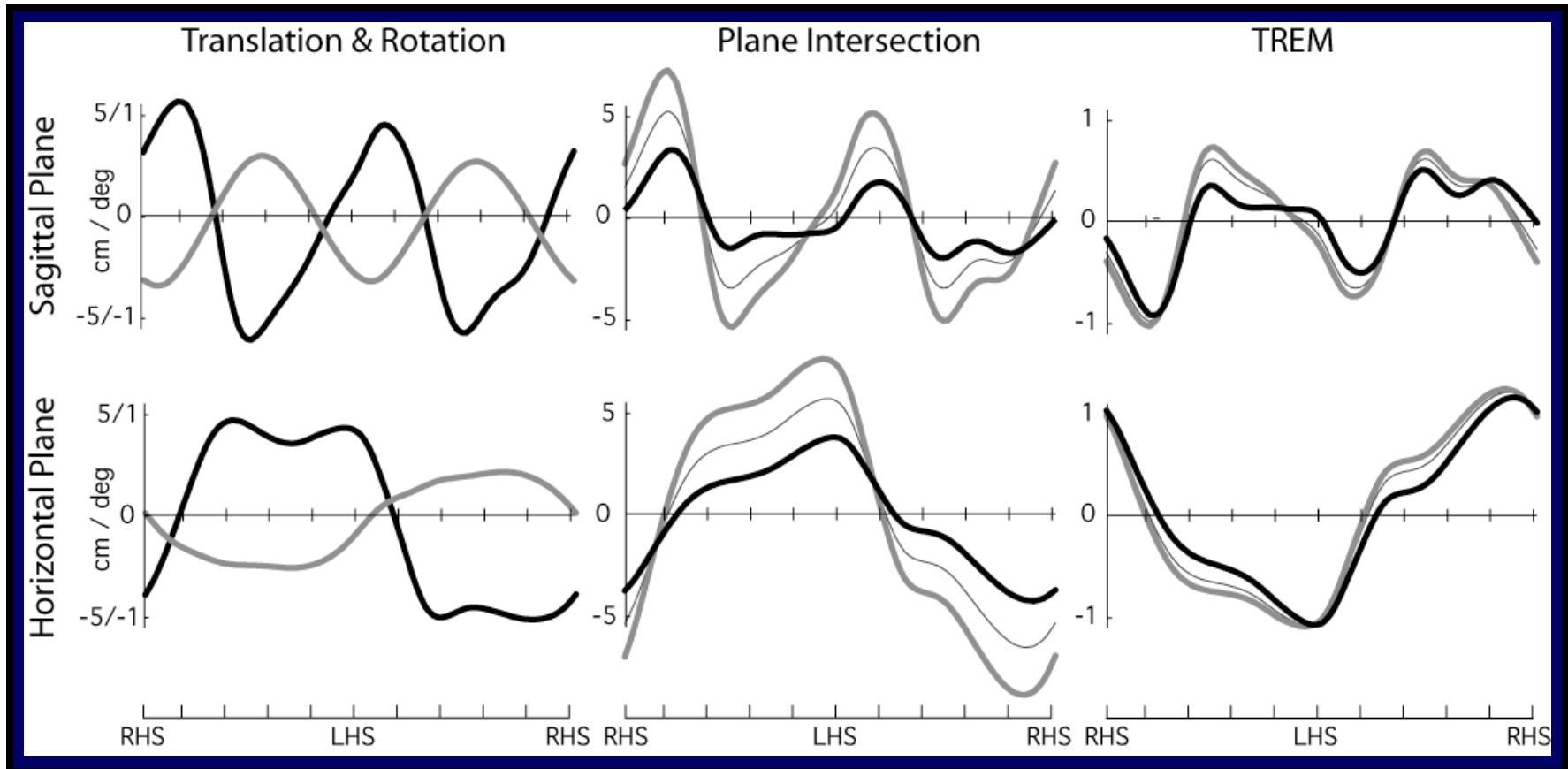
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**3.0 m**

# Required Eye Movements

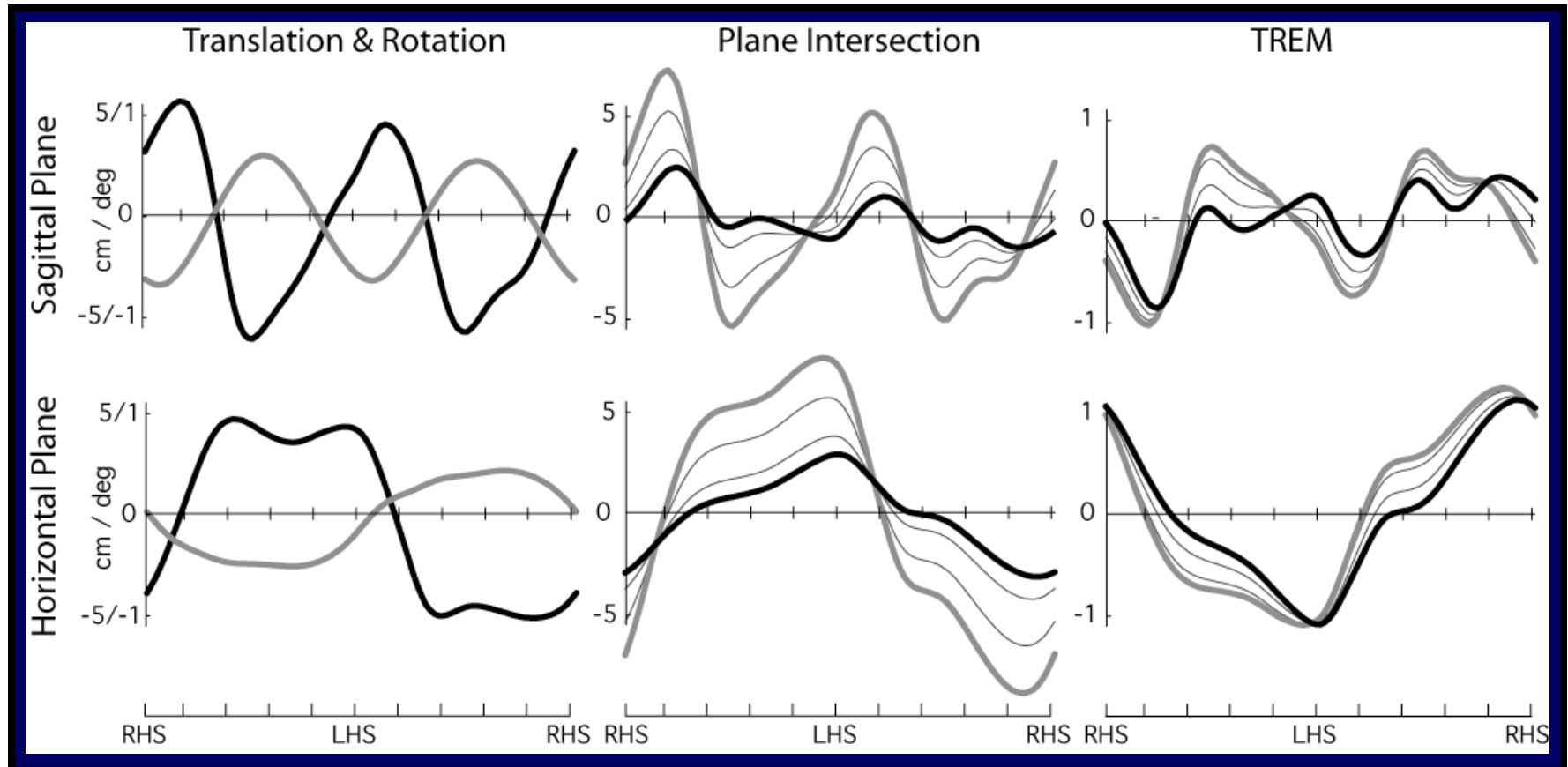
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**2.0 m**

# Required Eye Movements

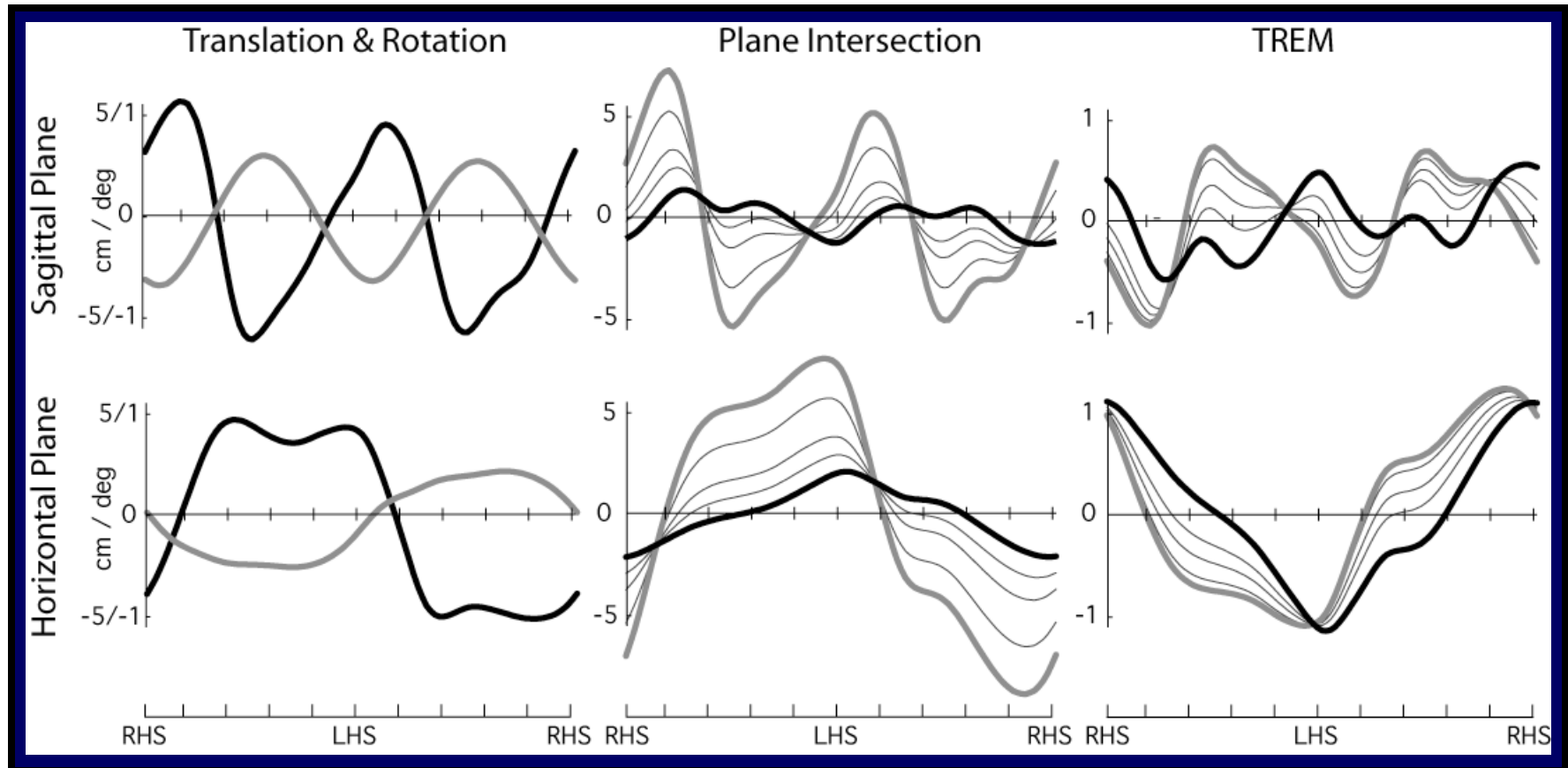
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**1.5 m**

# Required Eye Movements

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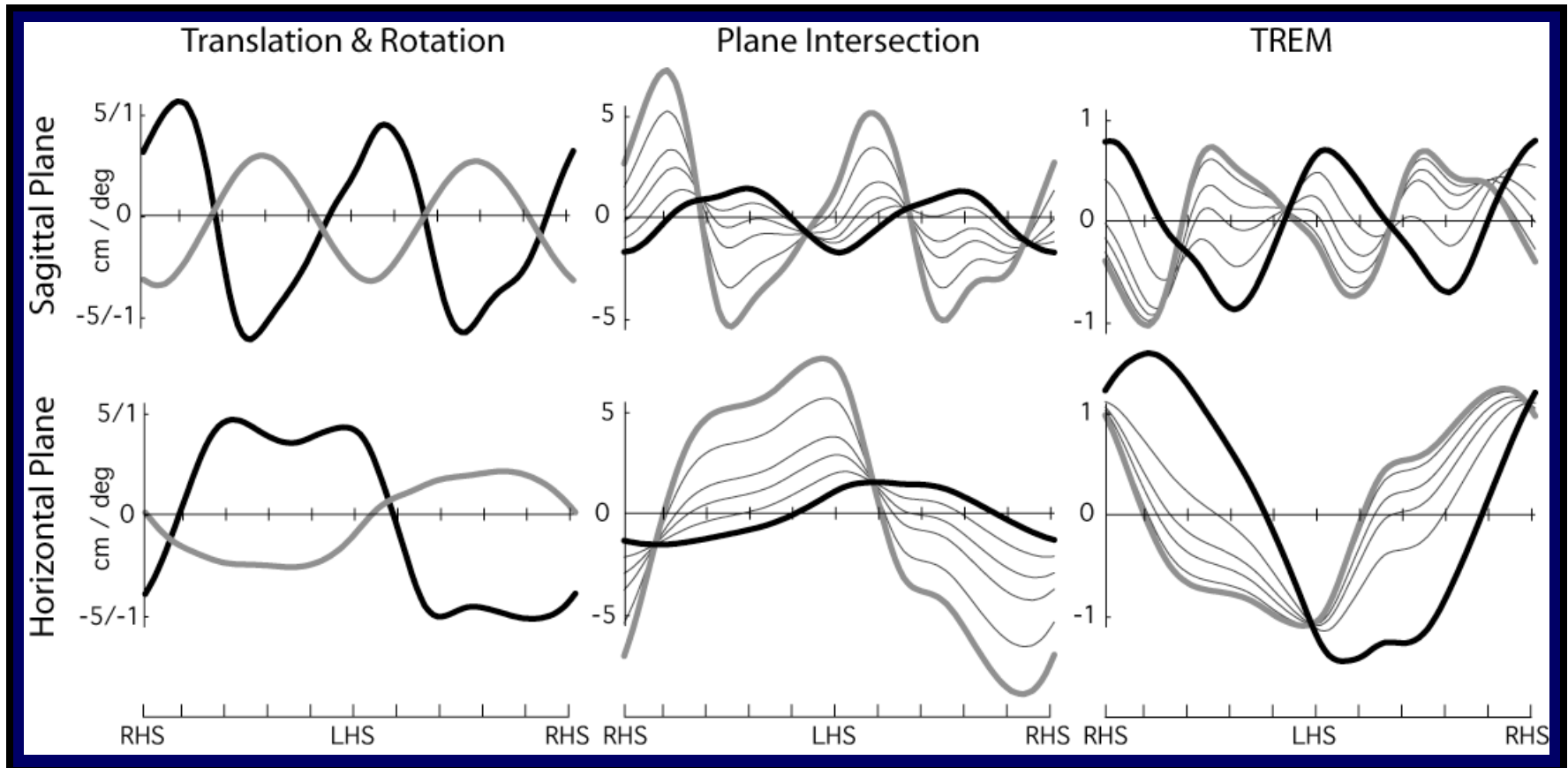


**1.0 m**



# Required Eye Movements

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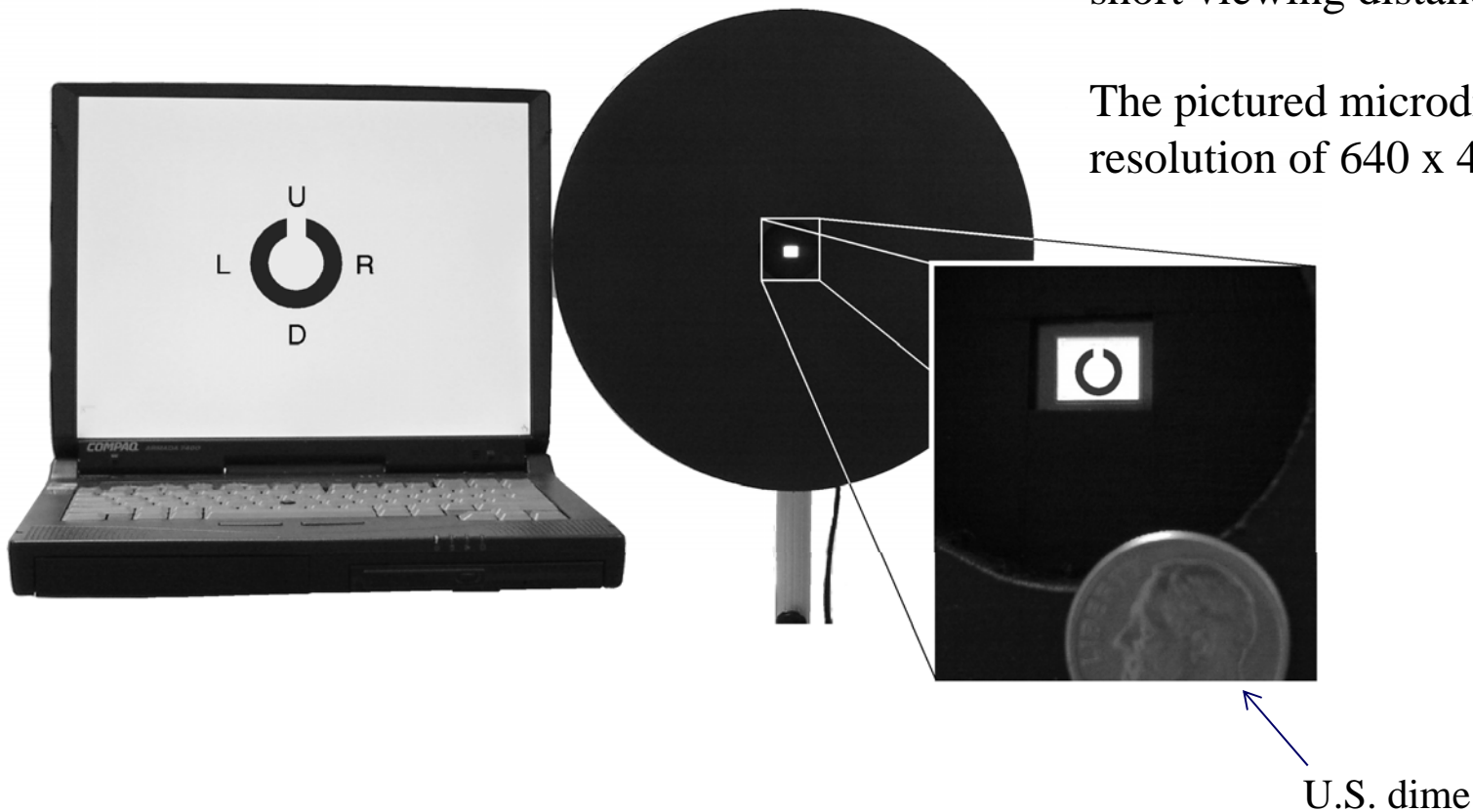
**0.5 m**

# Created ability to measure NEAR Acuity

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The screen resolutions on typical displays doesn't allow the clear presentation of small optotypes at short viewing distances

The pictured microdisplay has a resolution of 640 x 480



# FAR vs. NEAR DVA Results

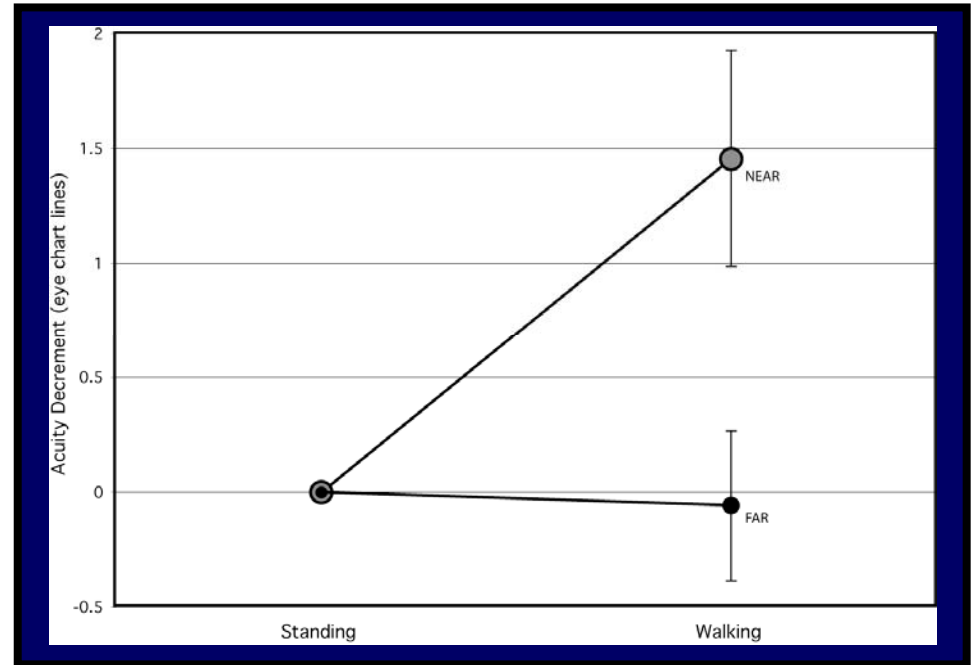
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Walking at 1.8 m/s

Display Duration: 500 ms

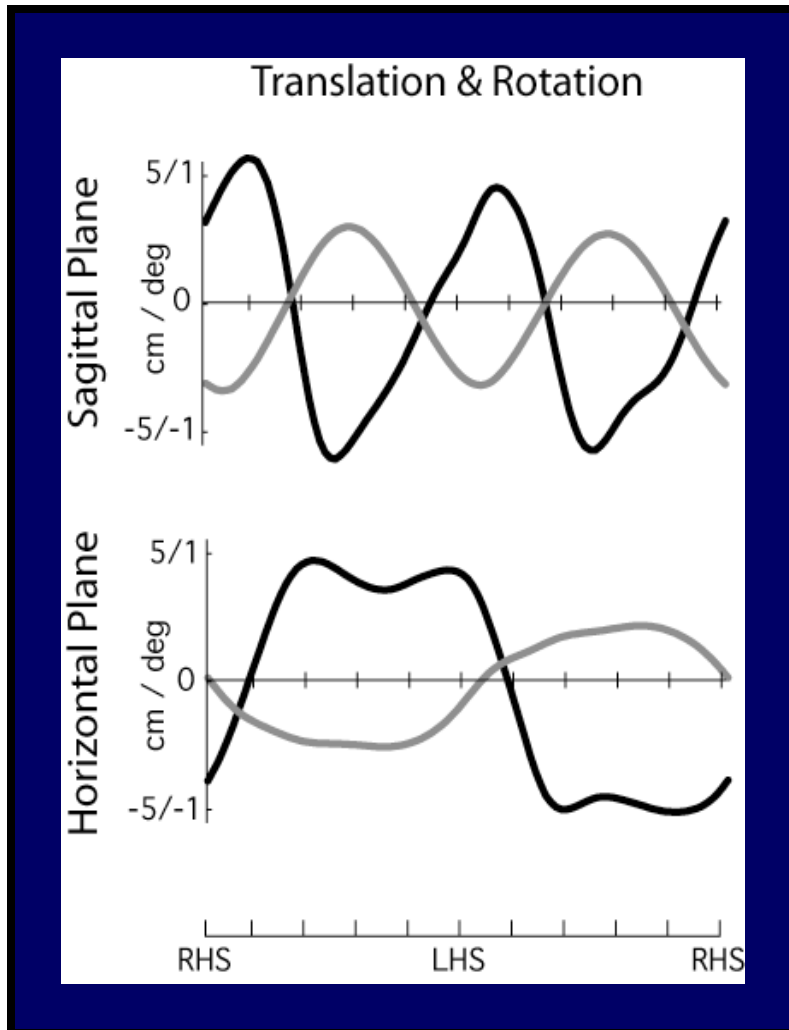
Comparison:

Target Distance  
4 m vs. 0.5 m



*Walking acuity is worse for NEAR targets*

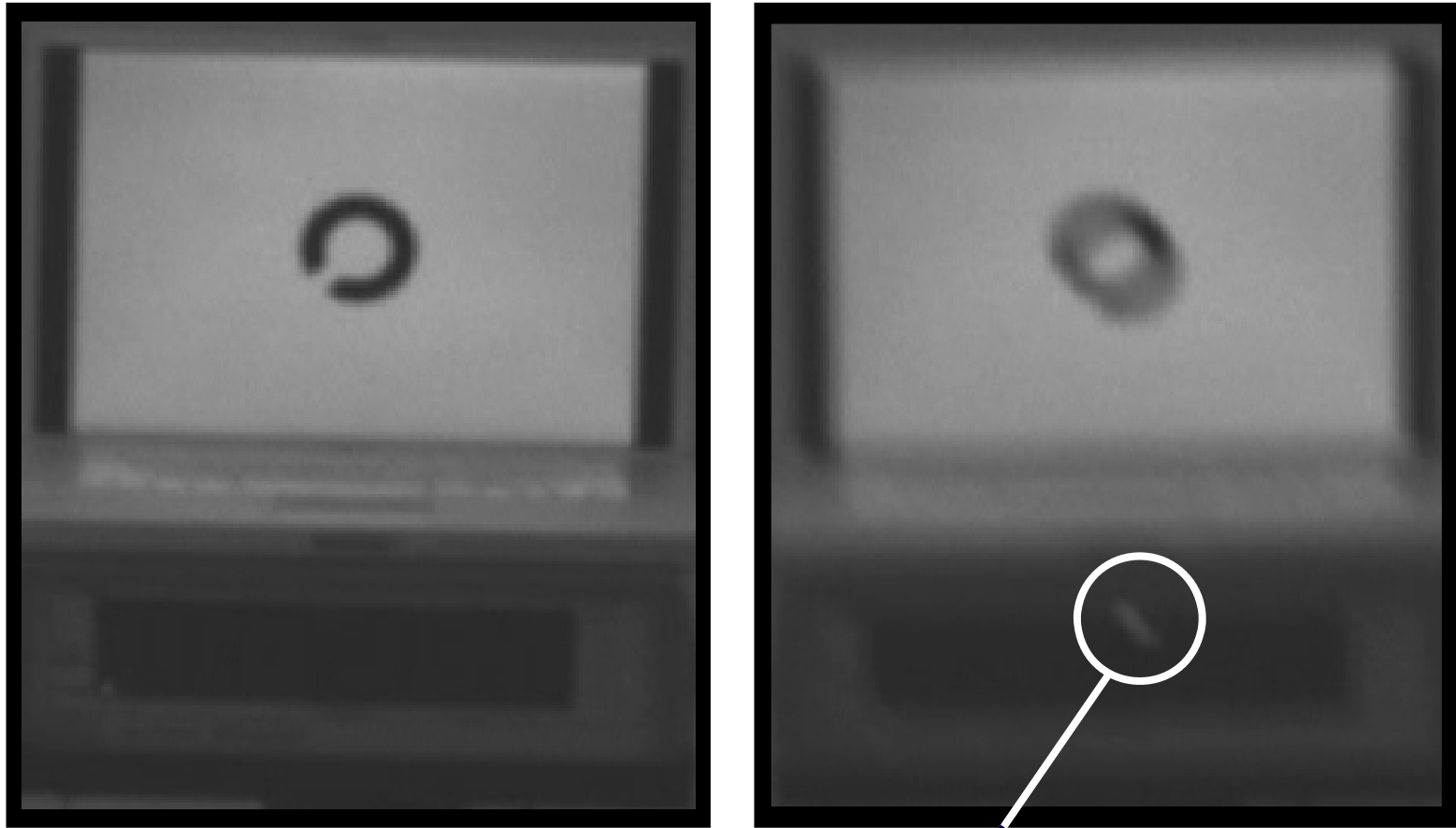
# Target distance also affects Head & Body movements



	<b>FAR</b>	<b>NEAR</b>	<b>p</b>
Vertical Trunk Translation	5.43 cm ± 0.64	4.85 cm ± 0.44	0.006
Head Pitch	3.58° ± 0.89	3.96° ± 0.70	0.167 8/11 ↑
Lateral Trunk Translation	3.56 cm ± 0.68	3.16 cm ± 0.46	<0.0001
Head Yaw	2.85° ± 0.68	3.29° ± 0.46	0.112 9/11 ↑

# Improving the DVA Test Sensitivity

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LED indicating heel contact

# Heel Strike vs. Mid-step DVA Results

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Walking at 1.8 m/s

Target Distance = 4 m

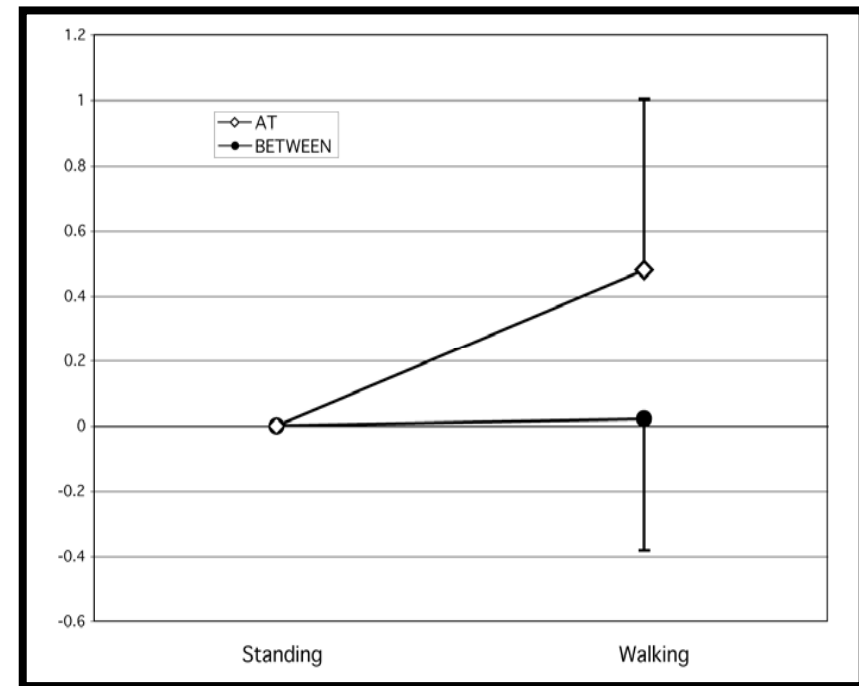
Display Duration: 75 ms

Comparison:

Gait Cycle Phase

“BETWEEN” vs. “AT” heelstrike

*Walking acuity is worse “AT” heelstrike*



# Passive DVA Test

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Because

- 2 of 3 ISS crewmembers couldn't walk on the treadmill at 1.8 m/s
- “Active” nature of the test could mask deficits *(Herdman et al. 2001)*

We created a passive DVA test

- vertical oscillations
- frequency & magnitude mimic walking



# Passive DVA Test Results #1

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Vertical Oscillation (2Hz, 5cm)

Target Distance = 2 m

Display Duration: 75 ms centered around peak velocity

Comparison: Control vs. Patients w/ vestibular dysfunction

*No Difference in DVA Between the Groups*



# Passive DVA Test Results #2

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Vertical Oscillation (2Hz, 5cm)

Target Distance = **4 m**

Display Duration: 75 ms & **500 ms**

Comparison: Control vs. Patients w/ vestibular dysfunction

*Difference in DVA only during 500 ms condition*

**Conclusion: Control subjects make better use of low velocity portion of perturbation**

# Conclusions

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- **Acuity is affected in returning crewmembers because of an inability to stabilize gaze**
- **Advantages of computer-based acuity test include:**
  - **randomized optotype orientations**
  - **NEAR and FAR viewing distances**
  - **triggered display**
- **DVA is affected by**
  - **target distance**
  - **display timing & duration**
  - **active vs. passive perturbation**